MIGRATORY BEHAVIOR OF MATURING PINK SALMON

IN GASTINEAU CHANNEL, SOUTHEAST ALASKA

by

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A

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ABSTRACT

Migration and spawning stream selection of maturing pink salmon in the area of Gastineau Channel was studied with respect to: (1) homing of individuals tagged with coded-wire as emergent fry; (2) intermingling and subsequent spawning locus of adults tagged at stream mouths; (3) migratory pathways into Gastineau Channel of fish tagged at north and south entrances; and (4) effects of stress (capture, handling and tagging) on pre-spawning adults in their natal stream on subsequent homing or straying.

(1) wire-tagged adults did not stray from two natal streams; (2) of 681 adults marked at stream mouths, 308 were recovered locally, demonstrating complex stock assemblages at some stream mouths and homogeneity at others; (3) of 949 adults tagged at entrances, 300 were recovered locally demonstrating intermingling of stocks at both entrances and differences in the proportions of each stock at each entrance; (4) stress induced straying (2%) from a natal to another stream one kilometer distant.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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INTRODUCTION

Knowledge of migration timing, stock composition in milling and harvest areas and general migratory behavior of returning adult pink salmon (Oncorhynchus gorbuscha) is important for the sound management of commercial fisheries, brood stock, and surplus returns by hatchery operators. The passage of the Private Non-Profit Hatchery Act and the establishment of Regional Aquaculture Associations has resulted in the construction and operation of many new hatcheries in Alaska, particularly Southeast Alaska. Pink salmon, because of their relatively short life cycle, have been used frequently in the initial phase of operation of many facilities and as the primary species of culture in others. The interaction of the new, hatchery produced fish and the wild runs of pink salmon in the traditional fishing areas has complicated the sound biological management of these fisheries. Cost recovery and broodstock acquisition by hatchery operators is also complicated by the presence of wild fish and fish from other hatcheries. Ideally, hatcheries have been situated where interactions with nearby wild runs are minimal and still allow for "substantial" contribution to the common property fisheries.

In 1981, I initiated a series of experiments to examine the migration behavior of pink salmon in the final phase of marine life. Gastineau Channel, in Southeast Alaska was chosen as the site for these

experiments because of the presence of several native runs of pink salmon and four hatcheries producing pink salmon on or near the Channel. All of these facilities had hatchery produced runs of pink salmon returning in 1982 and 1984.

The initial experiments, conducted with the 1980 brood year, focused on homing and stock composition at stream mouths. Results of these two experiments suggested two additional experiments with the 1982 brood. These subsequent studies examined the stock composition at the entrances to Gastineau Channel and the effects of tagging and handling stress on home stream fidelity.

Pink salmon migrations in southeast Alaska have been studied extensively beginning with the work of Rich (1927), then Rich and Suomela (1929); Nakatani et al., (1975) and Verhoeven, (1953). This early work focused on capturing pink salmon with commercial purse seines or traps, tagging them, and recovering the tagged fish in the commercial fishery. Determination of timing and principal migration corridors were the primary goals. Later work (Vania et al., 1964; Larson, 1978, 1979) recovered tagged fish in the spawning streams which had been tagged in the traditional commercial fishing areas. Stock composition in milling areas outside of the traditional fishing areas and near stream mouths has been the least studied aspect of the final phase of the anadromous migration of pink salmon.

The precision of homing of adult pink salmon to their natal stream has been discussed by many authors since the early work at McClinton Creek, British Columbia by Pritchard in the 1930's (Pritchard, 1939). Results there indicated imprecise homing for a small percentage of the return. Rapid expansion of pink salmon to dozens of spawning streams in the Great Lakes of North America (Kwain and Laurie 1981) and the colonization of Norwegian rivers by transplants to the White Sea from Kamchatka (Berg, 1977) could not have occurred without straying which has been postulated by Quinn (1984) as an alternative survival strategy. This lack of fidelity to the natal stream is also demonstrated by the rapid recolonization of the streams in Glacier Bay after the receding of the glaciers in the 1800's and early 1900's (i.e., Stream Nos. 114-73-10150; 114-73-10050; 114-72-10170 etc; Anon., 1986). The precision of homing, or sensitivity to stress induced straying, could have important economic and or biologic consequences to hatchery operations in close proximity using different stocks and to nearby wild stocks.

Tagging work in Puget Sound by DeLacy and Neave (1947) was the first work suggesting that pink salmon congregating relatively near the mouth of a river had not necessarily concluded their saltwater migration and might migrate somewhere else to spawn. Work by Helle (1966), indicated that accumulations of fish at the mouth of Olsen Creek in Prince William Sound were probably a mixture of stocks, ultimately bound for different streams. Information about movement patterns of pink salmon near stream mouths in Southeast Alaska was lacking until

1982. Stream mouth tagging had been attempted by Verhoeven in 1948 although he was not successful in capturing significant numbers of fish.

Only one previous study has examined movement patterns of adult pink salmon in the marine waters near Gastineau Channel (Rich and Suomela, 1927). That study, however, did not survey spawning streams for tag recoveries and indicated only which fisheries intercepted fish tagged at a given time in a specific location. Although the tagging was carried out near the northeast corner of Douglas Island, little information about Gastineau Channel spawning stocks was obtained. Although many tagging studies have been carried out in Northern Southeast Alaska, (Rich, 1927; Rich and Suomela, 1929; Nakatani et al., 1975; Verhoeven, 1953), extensive surveys were generally lacking and, for Gastineau Channel streams, were nonexistent until the work of Vania, et al., (1964). In that study, a few recoveries of Gastineau Channel pink stocks were made. It was not until the work of Larson in 1977 and 1978 that significant numbers of tagged fish were recovered in local streams, primarily Fish Creek and Auke Creek. These recoveries provided timing information for those stocks through the Point Augusta and Hawk Inlet area of upper Chatham Strait.

The tagging work reported by Helle in 1966 demonstrated that pink salmon tagged in freshwater in Olsen Creek left that stream and spawned in other nearby streams. Helle concluded that those fish were a mixture of stocks but did not consider the possibility of stress induced straying.

The first experiment I initiated was conducted in 1981 with the 1980 brood year of pink salmon at Salmon Creek Hatchery and had three primary goals: (1) to determine if emergent pink salmon could be successfully tagged with half length coded-wire tags; (2) to determine if native Salmon Creek stock would stray and spawn in nearby streams; and (3) to determine if the fish that home correctly could be induced to stray and spawn in another stream if denied access to a portion of the stream. In 1982, I attempted to determine stock composition of schools of salmon congregating near the mouths of five streams in Gastineau Channel by capturing and tagging fish in the stream mouths and recovering tagged fish in their respective spawning streams. In 1984, I attempted to determine stock composition of pink salmon captured at the two entrances to Gastineau Channel by purse seining and tagging throughout the migration period and subsequent recovery of tagged adults in the local spawning streams. I also conducted an experiment in 1984 at Auke Creek using native Auke Creek stock to determine if stress, simulated by tagging and handling, and/or denial to a particular portion of a spawning stream might induce fish returning to their natal stream to spawn in another stream.

The combination of these four experiments was designed to provide a clearer understanding of the migration behavior of pink salmon in the Gastineau Channel area specifically, and to provide a better understanding of the fidelity of homing to natal streams in this species.

Study Site

Gastineau Channel, located in Northern Southeast Alaska, is a fjord-like extension of Stephens Passage, and separates Douglas Island from the mainland (Figure 1). The southern end of the channel opens into Taku Inlet and averages about 90 meters in depth at this juncture. The northern end connects to Fritz Cove and is a shallow, dredged canal which goes dry at tides lower than ten feet above mean lower low water. From Fish Creek, which empties into the northwest end of the channel, to Marmion Island at the southern, Gastineau Channel is approximately 45 kilometers (25 miles) in length.

Mainland streams on the east side of Gastineau Channel involved in the study were: Sheep Creek, Gold Creek, Salmon Creek, Lemon Creek, Switzer Creek, and Montana Creek. Two streams located to the north of the channel were also involved in the study: Auke Creek and Waydelich Creek both draining into Auke Bay. Douglas Island streams on the west side of Gastineau Channel involved in the study were: Nevada Creek, Bullion Creek, Ready Bullion Creek, Bear Creek, Lawson Creek, Kowee Creek, Eagle Creek, Fish Creek, and Peterson Creek.

The study streams are generally characterized by having a steep gradient with a barrier falls a short distance upstream from tidewater. Some exceptions to this are: Fish Creek, having a lower gradient and a barrier falls three kilometers (1.67 miles) from tidewater; Switzer Creek, primarily low gradient and spring fed; Peterson Creek, low gradient; and Auke Creek, lake fed with no barrier falls.

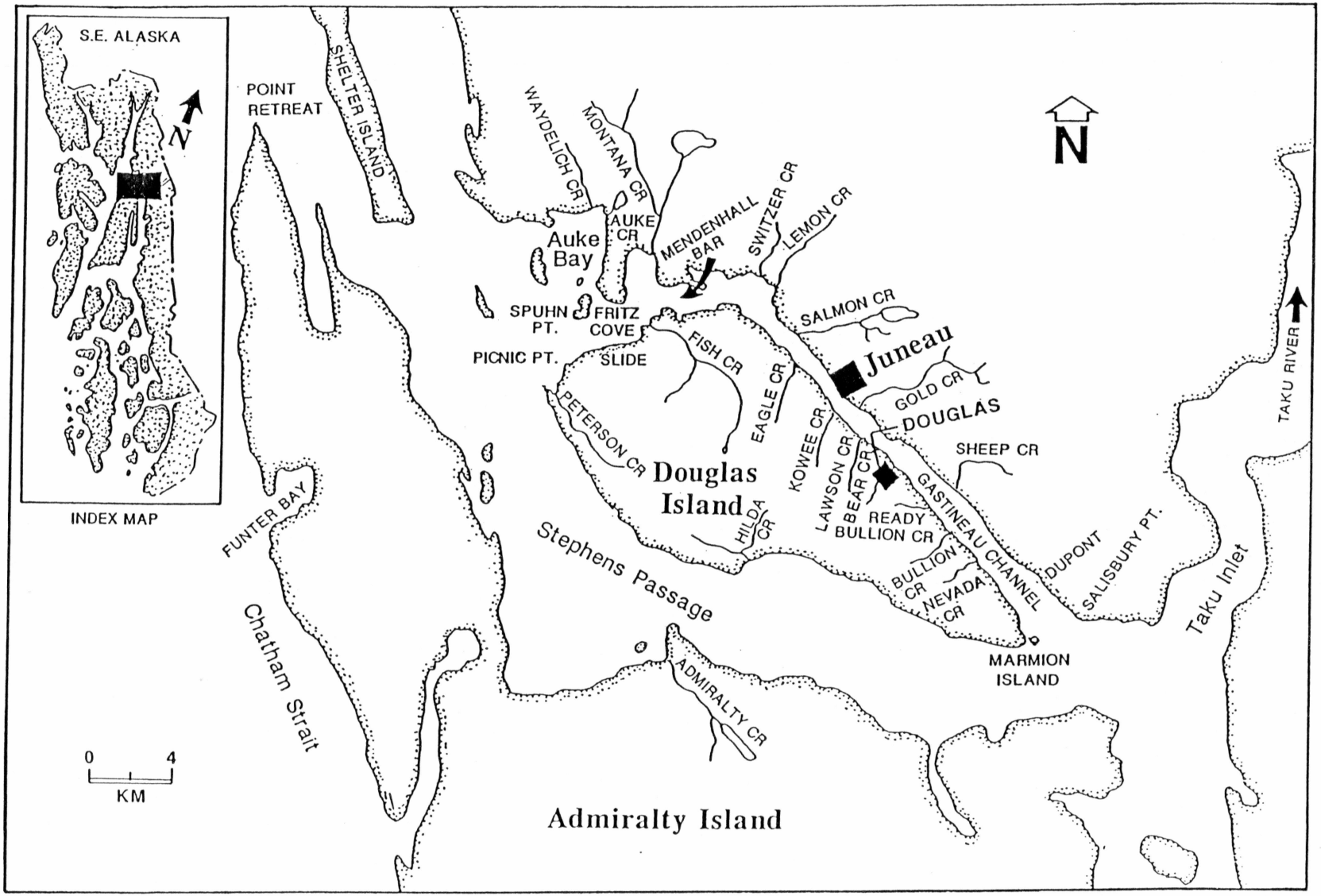

Figure 1. Gastineau Channel, Southeast Alaska, and associated pink salmon spawning streams.

All the streams mentioned in the study area have natural or hatchery produced runs of even year pink salmon which generally spawn in the intertidal zone. Auke Creek, Switzer Creek, Montana Creek and Lemon Creek have populations of which a substantial portion spawn above the intertidal zone.

Four hatcheries were located within the study area that produced returns of pink salmon in 1982 and 1984: Auke Creek Hatchery on Auke Creek, approximately 3.6 kilometers (2 miles) north of Gastineau Channel; Salmon Creek Hatchery on Salmon Creek 5.4 kilometers (3 miles) north of the town of Juneau; Kowee Creek Hatchery on Kowee Creek, Douglas Island and Sheep Creek Hatchery, on Sheep Creek 12.6 kilometers (7 miles) south of Juneau.

Methods

I. The 1982 Homing Experiment

The primary objective of the 1982 homing experiment was to determine whether pink salmon, marked with coded-wire tags as emergent fry in their natal stream, would return to spawn in any nearby streams other than their natal stream.

A. Tagging Procedures

In May, 1981, 9,338 emergent pink salmon were tagged with half-length (0.5 x 0.25 mm) binary-coded wires. Their adipose fins were removed and they were released unfed on May 1 from Salmon Creek Hatchery (Thrower and Smoker 1984). These fry were progeny of native stock that returned to Salmon Creek in August 1980. The tagged adults returning in 1982 were captured on the spawning grounds in the intertidal portion of Salmon Creek at low tide.

Three thousand fourteen emergent fry were also tagged in the same manner at Auke Creek Hatchery and released May 10, 1981, into Auke Creek. The parents of these fry had been captured at the weir on Auke Creek in 1980.

B. Recovery Procedures

Adults returning to streams in the study area in 1982 were captured and examined for missing adipose fins and external tags used in other experiments at weirs on four of the five principle spawning streams in the area: Auke Creek, Salmon Creek, Kowee Creek and Sheep Creek. The largest natural run in the area, Fish Creek, was monitored by hatchery personnel who were using this run as an egg source for their hatcheries (Douglas Island Pink and Chum, Inc., [DIPAC]). This stream was surveyed, on foot, daily by DIPAC personnel and frequently by myself and technicians of the Alaska Department of Fish and Game (ADF&G).

I examined carcasses for tags on all the study streams in both 1982 and 1984. Adults recovered with missing adipose fins were decapitated and the heads examined by x-ray at Bartlett Memorial Hospital, Juneau, to determine the presence of a tag. The tags were then dissected from the heads and decoded under a magnifier.

II. The 1982 Stream Mouth Tagging Experiment

The tagging of adults near stream mouths in Gastineau Channel in 1982 was conducted to determine the run composition of schools of salmon congregating near the mouths of the main spawning streams in the channel.

A. Tagging Procedures

Adult pink salmon returning to Gastineau Channel in 1982 were captured by purse seine, beach seine, sport gear, and weirs. Each fish was removed from the water by hand or dipnet and a numbered Floy Tag (model FD67-B) was inserted below the dorsal fin, through the pterygiophores. The fish was then returned to the water. Principal tagging locations were: Salmon Creek, Kowee Creek, Lawson Creek, Bullion Creek and Sheep Creek (Figure 2).

Captures of fish to be tagged were made in marine waters within 30 meters (100 feet) of the stream mouth of the target stream with the following exceptions: Salmon Creek, where fish were captured at a weir in the high intertidal zone between Egan Expressway and Glacier Highway; Marmion Island, at the southern end of the channel; and one purse seine set at the day marker approximately 300 meters (1,000 feet) from the mouth of Sheep Creek.

A purse seine, approximately 227 meters (750 feet) long and 12 meters (40 feet) deep, fished by a commercial seine boat and skiff, was used to capture adults near the mouth of Sheep and Bullion Creeks and the eastern shoreline of Marmion Island.

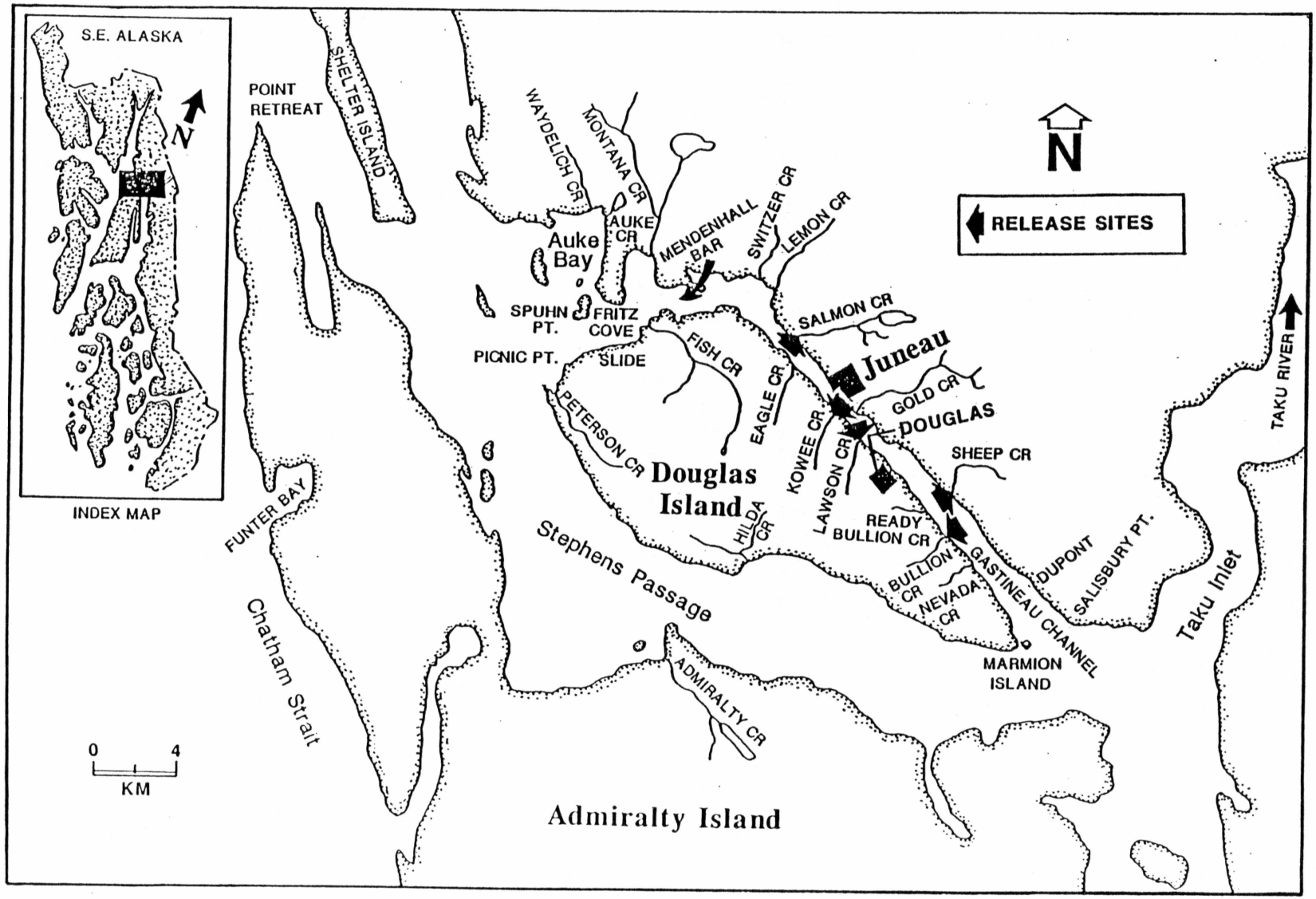

Figure 2. Capture and release sites for the 1982 stream mouth tagging experiment.

A 35 meter (115 feet) beach seine three meters (10 feet) deep was used to capture adults near the stream mouths of Bullion, Kowee and Sheep Creeks.

A spinning rod and reel with a gold and orange Pixie® lure and eight pound test line was used to capture adults near the mouths of Bullion, Sheep, Lawson, Salmon, and Kowee Creeks.

The Floy tags used in this experiment were color-coded by stream, each stream represented by a different colored tag. The tags were serially numbered with each tag having the same number repeated four times along its length. This was done to facilitate data collection in the field (a portion of the tag was snipped off and retained for recording later) and also to enable recognition of fish that had been previously sampled.

B. Recovery Procedure

Tagged fish, recovered on the streams with weirs by hatchery personnel, were usually sacrificed for spawning and the tags removed. I captured tagged fish with a dipnet on other study streams, removed one copy of the number of the tag and returned the fish to the stream. When the stream was resurveyed, generally no attempt was made to capture those fish with a tag of a color coded for that stream and of shortened length.

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ADF&G technicians sampled commercial gillnet and seine catches throughout Southeast Alaska and made foot surveys of many spawning streams outside the study area during the season. They also operated fish wheels at Canyon Island on the Taku River and examined captured pink salmon for tags.

Radio announcements of the tagging program were made to encourage sport fishermen to return tagged fish.

III. The 1984 Channel Mouth Tagging Experiment

Adult pink salmon were tagged at the northern and southern entrances to Gastineau Channel in 1984 to determine run composition and timing of Gastineau Channel stocks in those areas.

A. Tagging Procedures

In 1984, a commercial salmon seine boat (F/V Anne) was chartered by ADF&G to determine the suitability of Fritz Cove and lower Gastineau Channel as terminal harvest area for surplus hatchery production. A standard commercial purse seine 455 meters long (1,500 feet) and 36 meters deep (120 feet) was fished once per day, one day per week from July 13 through August 1. A slightly smaller seine (364 meters long) and different boat (F/V Daybreak) fished August 8 and 17.

Both vessels fished at three sites in Fritz Cove and three sites in southern Gastineau Channel (Figure 3). The only exceptions to this were two sites in the southern channel area which were not fished July 13 (Marmion Island and DuPont) and one site in Fritz Cove which not fished July 26 (Spuhn Point). I tagged and released adult pink and chum salmon captured during this sampling.

Usually, two tagging crews were used. One team applied Floy tags as previously described, and the other crew applied one inch Peterson disc tags in which a nickel pin with one disc was inserted through the dorsal musculature (in the same location as the Floy tags) and out the other side of the fish. Another disc was placed on the pin and the excess metal cut off. The pin was then folded once with needle-nose pliers to secure the discs firmly against the sides of the fish. Only one tag was used per fish. Two types of tags were used to determine if recovery rates would be different.

The captured fish were dipnetted one at a time from the bunt of the purse seine, which was held open by the seine skiff, and were tagged and released. Orange colored tags were used for both Floy and most disc tagging. Pink colored disc tags were used on the last two tagging dates at all sites.

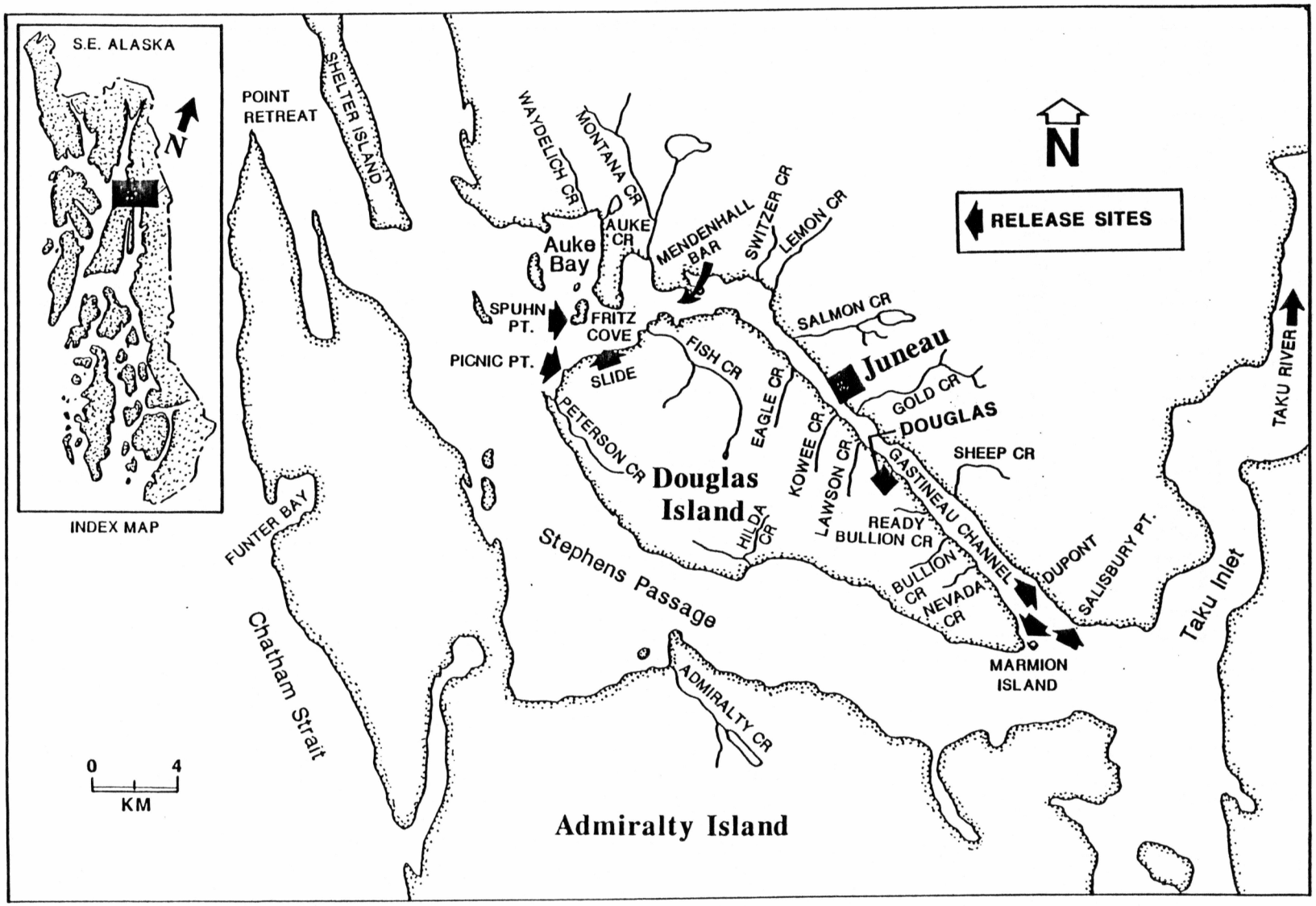

Figure 3. Capture and release sites for the 1984 channel mouth tagging experiment.

B. Recovery Procedures

Recovery procedures in 1984 were basically the same as in 1982 except no weir was available at Salmon Creek so foot surveys were conducted on intervals of two or three days. At Salmon Creek, UAJ graduate students seined samples of salmon to recover coded-wire tagged chum salmon. In addition, they recovered Floy or disc tagged pink salmon. Also different in 1984 was that upon first capture, the tag was removed from the fish, so when possible, all tags were removed from the stream each survey.

IV. The 1984 Stress Experiment

Tagging and denial to upstream spawning areas was used to stress pre-spawning salmon, known to be native to Auke Creek, to determine if this stress would induce them to spawn in adjacent streams.

A. Tagging Procedures

The Auke Creek weir was used to capture returning, fin-marked pink salmon in 1984. As fry, these fish had been marked by removing both the adipose and one ventral fin. These fry were the progeny of a genetic tagging experiment that had been conducted with the even year run at Auke Creek for two generations to enable identification of individuals by the presence of a naturally rare allele (Lane, 1984). Adults were dipnetted from the trap at the weir, examined for missing

fins, and equal numbers of marked and unmarked (control) fish were held for tagging until the trap had been emptied. A plug of tissue was later removed with a coring tool just posterior to the insertion of the dorsal fin to check for the presence of the genetic mark. A Peterson disc tag was attached in the method previously described and the fish were released immediately downstream from the weir. One pink and one orange disc were used on the genetically marked fish and orange discs were used on the control fish.

B. Recovery Procedures

At Auke Creek, all marked fish that returned to the weir trap were released downstream again and recorded.

Stream survey effort for tagged fish from this experiment was similar to that of the 1984 Channel Mouth Experiment except tagged fish in the inter-tidal portion of Auke Creek were not recaptured.

Results

I. The 1982 Homing Study

Of the 9,338 tagged fry released from Salmon Creek in 1981, 17 tagged adults (0.18%) were recovered in Salmon Creek in July and August, 1982 (Thrower and Smoker, 1984). No adults bearing the Salmon creek tag codes (B4 02/00 and B4 08/08) were recovered in any other stream. Five fish with missing adipose fins but no coded-wire tags were also found in Salmon Creek.

Of the 3,018 tagged fry released from Auke Creek Hatchery in 1981, four tagged adults (0.13%) bearing the Auke Creek tag code (B4 08/09) were recovered in the Auke Creek trap. No adults with this code were recovered in any other stream. Five fish with missing adipose fins and whose ventral fins did not appear to have been clipped but that did not have coded-wire tags were also recovered at the trap.

I recovered one fish with a missing adipose fin from Bullion Creek and one from Kowee Creek. Neither fish had a coded-wire tag.

II. The 1982 Stream Tagging Mouth Experiment

A total of 681 pink salmon was tagged in this experiment in 1982. Three hundred eight (45.2%) were recovered, all from streams within the study area (Table 1). Fish tagged at the mouth of Bullion Creek and Lawson Creek (Figure 4) were recovered in six other streams (Table 1). Fish tagged at Kowee Creek were recovered in three other streams and those tagged at Salmon and Sheep Creeks were recovered in one other stream each. Of the nine fish tagged at Marmion Island, only one was recovered and that was in Fish Creek.

Purse seining was ineffective in capturing adult pink salmon in this study. The poor return to lower Gastineau Channel in 1982 (18,500 - 22,500 fish), where the seine effort was concentrated, and the preference of the fish for shallow water usually less than five m (16.5 feet) deep, resulted in the capture and tagging of only 24 pink salmon (3.5% of total tagged).

Beach seining was attempted at all five stream mouth sites and accounted for 210 (30.8%) of the total fish tagged. Beach seining was effective at Kowee and Bullion Creeks where the receding tide could be used to trap the adults in the stream channel. Ninety-five fish at Kowee Creek and 114 at Bullion Creek were captured in this manner.

Table 1. Recoveries of pink salmon tagged and released in Gastineau Channel, 1982.

Recovery Site	Release Site						
	Bullion Creek	Kowee Creek	Salmon Creek	Sheep Creek	Lawson Creek	Marmion Island	Unknown[1]
Bullion Creek	95						
Kowee Creek	4+2[2]	88[3]	2		18		
Salmon Creek	2	1	32	1	+1[2]		
Sheep Creek	5			26	1		
Lawson Creek	2[3]	2+1[2]			2+6[2]		
Nevada Creek	4						
Bear Creek					+1[2]		
Eagle Creek		2+4[2]					
Ready Bullion Ck.	2				+1[2]		
Fish Creek					1	1	+1[2]
Total Recovered	116	96	34	27	31	1	Total 1 = 308
Total Tagged	193	192	136	81	70	9	681
Percent Recovered	60	51	25	33	44	11	45.2

[1]Tagged fish was sighted, but tag color not positively identified.

[2](+) indicates a tagged fish sighted but not recovered.

[3]One tag recovery by sport fishery in the mouth of the stream.

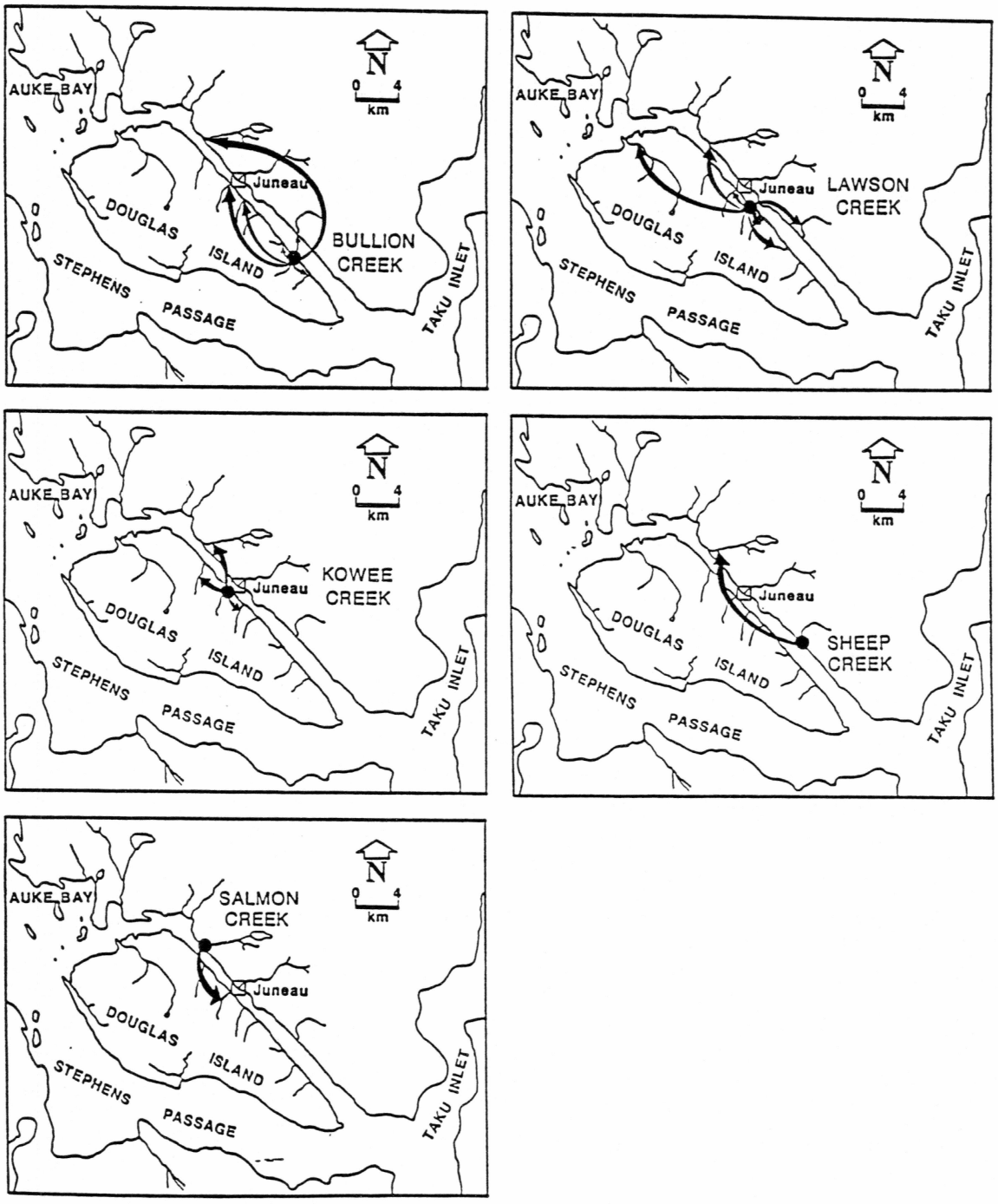

Figure 4. 1982 stream mouth tagging locations and subsequent tag recovery streams, by tagging location.

Weirs were used primarily at Salmon and Kowee Creeks to capture fish for tagging. At Kowee Creek, a weir was placed in the low intertidal zone, at the previous beach seine site, mid-way through the return and was subsequently used to capture and tag the adults. This weir was completely inundated at most high tides. Weirs accounted for 224 (32.9%) of the number tagged.

Hook and line fishing was effective at Lawson, Sheep and Bullion Creeks and accounted for 224 (32.9%) of the total number tagged.

Movement of tagged fish was highest from the Lawson Creek tagging, where, of the 70 fish tagged, 31 fish (44%) were recovered, 23 of these (74%) were recovered in other streams (Table 1). The majority, 78%, of the 23 fish recovered in other streams, were recovered from Kowee Creek.

The second largest movement was observed from the Bullion Creek tagging. Here, of the 193 fish tagged, 116 (60%) were recovered of which 21 (18%) were recovered in six other streams (Figure 4). The principle movement away from Bullion Creek was to Kowee Creek (6 fish; 29%) and Sheep Creek (5 fish; 24%) with Nevada, Ready Bullion, Lawson and Salmon Creeks receiving 19, 10, 10 and 10%, respectively. One fish, tagged at the mouth of Bullion Creek, I observed spawning in Bullion Creek eight days later. The same fish was subsequently recaptured in Nevada Creek four days later, still in good condition with freely running milt.

At Kowee Creek, 192 fish were tagged, of which 98 (51%) were recovered. Of these, six (6%) were recovered in Eagle Creek, three (3%) in Lawson Creek and one (1%) in Salmon Creek. The remaining fish were recovered in Kowee Creek.

Very little movement away from the stream of tagging was observed in fish tagged at Salmon Creek (136) or Sheep Creek (81) (Table 1). From the Salmon Creek tagging, 34 fish (25%) were recovered, of which two (6%) were recovered in Kowee Creek. These two fish had been tagged as mature males (freely running milt) and recovered in Kowee Creek shortly after heavy rains washed the weirs out on Salmon and Kowee Creeks. Twenty-seven fish (33%) of those tagged at Sheep Creek were recovered of which only one (4%) was recovered at another stream (Salmon Creek). This fish was unusual in that it was tagged about 300 meters from the mouth of Sheep Creek, and all of the other recovered fish had been tagged within 30 meters of the stream mouth.

III. The 1984 Channel Mouth Tagging Experiment

Nine hundred eighty-nine pink salmon were captured in 1984. Catches began relatively high in the southern area (DuPont, Marmion and Salisbury Point sites) (Figure 2), peaked during the second week of sampling and were almost zero by the sixth week. Catches in the northern area (Picnic Cove, the Slide and Spuhn Point sites) (Figure

2) started at almost zero the first week of sampling and increased only slightly to peak the fourth week and return to almost zero by the sixth week (Table 2).

Nine hundred forty pink salmon were tagged in this experiment in 1984. The three northern sites accounted for 121 fish (12.9%) of the total tagged. Of these, 57% were captured at the Slide, 31.4% at Spuhn Point and 11.6% at Picnic Cove. The three southern sites accounted for 819 fish (87.1%) of the total tagged. Of these, 73.7% were captured at Salisbury Point, 24.2% at DuPont, and 2.1% at Marmion (Table 3).

A total of 300 fish (31.9%) from the channel mouth experiment was recaptured in local streams, commercial and sport fisheries in 1984 (Table 3). Per cent recovery by tagging site was similar to the per cent released by tagging site (Table 3). Of those recovered, 16.3% were from the commercial and sport fisheries and 83.7% were recovered from spawning streams or the Sheep Creek special harvest area (SHA). Recoveries at Sheep Creek and the SHA totalled 65.5% of the total tagged fish recovered. Eight and three tenths percent were recovered from the Taku River, 4.0% from Salmon Creek, 3.3% from Fish Creek, 2.0% from Kowee Creek, 0.7% from Hilda Creek and 0.3% from Auke Creek (Table 4).

Table 2. Number of pink salmon caught and tagged by period for northern and southern Gastineau Channel, 1984.

Period	Date	Northern		Southern		Total	
		Captured	Tagged	Captured	Tagged	Captured	Tagged
1	7/13	5	3	85	75	90	78
2	7/19-20	22	17	331	310	353	327
3	7/25-26	7	5	167	167	174	172
4	8/1	53	53	143	138	196	191
5	8/7	34	33	122	120	156	153
6	8/17	10	10	10	9	20	19
	Total	131	121	858	819	989	940

Table 3. Catch and recovery by tagging site for pink salmon tagged in Gastineau Channel in 1984.

Tagging Site	Number Tagged	Percent of Total Tagged	Percent Within Area Tagged	Number Recovered	Percent of Total Recovered	Percent Within Area Recovered
Picnic Cove	14	1.5	11.6	5	1.7	13.9
The Slide	69	7.3	57.0	20	6.7	55.6
Spuhn Point	38	4.0	31.4	11	3.7	30.6
Total	121	12.9	100.0	36	12.0	100.1
DuPont	198	21.1	24.2	74	24.7	28.0
Marmion Island	17	1.8	2.1	4	1.3	1.5
Salisbury Point	604	64.3	73.7	186	62.0	70.5
Total	819	87.1	100.0	264	88.0	100.0
Grand Total	940	100.0		300	100.0	

Six hundred fifty-two fish (69.4%) were tagged with Floy tags and 288 (30.6%) were tagged with Peterson disc tags. One hundred ninety-eight Floy tagged fish (66.0%) and 102 disc tagged fish (34.0%) were recovered. There was no significant difference between the ratio of Floy to disc tagged fish released and the ratio of Floy and disc tagged fish recovered (Floy Tags: 69.4% of release, 66.0% of recovery; Disc Tags: 30.6% of release, 34.0% of recovery) ($G = 1.565$ 1 df).

Percent composition of recoveries by time and area for the principal spawning stocks is shown in Table 5. Recoveries at Sheep Creek came primarily from fish tagged in the second and third weeks. No fish were recovered from the sixth week of tagging. Recoveries of tagged fish on the Taku River came primarily from the first and second weeks of tagging, no fish from the fifth or sixth week were recovered in the Taku River. Recoveries from Fish, Salmon and Kowee Creeks were predominantly from fish tagged the second week of tagging.

Eight-hundred thirty-eight chum salmon (O. keta) were also tagged and this information is summarized by Thrower and Smoker, (1985).

No fish tagged in the northern area were recovered in the Taku River and less than 10% of the Sheep Creek recoveries came from this area. Conversely, a significant portion of the recoveries from Salmon, Fish and Kowee Creeks came from the northern end tagging (58%, 50% and 33%, respectively (Figure 5).

Table 4. Summary of pink salmon captured, tagged and recovered from the Gastineau Channel Tagging Experiment in 1984.

Tagging Date	Tagging Location	Number Tagged	Total Captured	Fish Creek	Salmon Creek	Kowee Creek	Sheep Creek	Sheep Creek SHA	Auke Creek	Hilda Creek	Taku River	Commercial Fisheries			Sport Fishery	Total Recaptured	Percent Recaptured
												Gillnet	Seine	Troll			
	Picnic Cove	3	4														
	Slide	0	1														
7/13	Spuhn Point	0	0														
	DuPont	-	-														
	Marmion	-	-														
	Salisbury Pt.	75	85				2	4			6	9				21	
		78	90				2	4			6	9				21	26.9
	Picnic Cove	4	4				3									3	
7/20	Slide	7	7			1	2					1				4	
	Spuhn Point	6	11	1			1					2				4	
	DuPont	41	41	1		1	10	5				3				20	
7/19	Marmion	5	6		1							1				2	
	Salisbury Pt.	264	284	3	3	1	30	37			16	8	2			100	
		327	353	5	4	3	46	42			16	15	2			133	40.7
	Picnic Cove	0	2													0	
7/26	Slide	5	5					1								1	
	Spuhn Point	-	-													0	
	DuPont	95	95			1	21	16		1	2	2		1		44	
7/25	Marmion	7	7				2									2	
	Salisbury Pt.	65	65		1		6	8		1		4	1			21	
		172	174		1	1	29	25		2	2	6	1	1		68	39.5
	Picnic Cove	4	4													0	
	Slide	20	20	1	1	1	2	1								6	
8/1	Spuhn Point	29	29		2		2	1				1			1	7	
	DuPont	23	24				1	2								3	
	Marmion	0	0													0	
	Salisbury Pt.	115	119				13	3			1	4				21	
		191	196	1	3	1	18	7			1	5			1	37	19.4

Table 4. (Continued)

Tagging Date	Tagging Location	Number Tagged	Total Captured	Fish Creek	Salmon Creek	Kowee Creek	Sheep Creek	Sheep Creek SHA	Auke Creek	Hilda Creek	Taku River	Commercial Fisheries Gillnet	Commercial Fisheries Seine	Commercial Fisheries Troll	Sport Fishery	Total Recaptured	Percent Recaptured
	Picnic Cove	1	1		1											1	
	Slide	30	31	3	2		1		1							7	
8/7	Spuhn Point	2	2													0	
	DuPont	37	37				4					2	1			7	
	Marmion	4	4													0	
	Salisbury Pt.	79	81	1		1	17					3			1	23	
		153	156	4	3	1	22		1			5	1		1	38	24.8
	Picnic Cove	2	2		1											1	
	Slide	7	7									1			1	2	
8/17	Spuhn Point	1	1													0	
	Dupont	2	2													0	
	Marmion	1	2													0	
	Salisbury Pt.	6	6													0	
		19	20		1							1			1	3	15.8
	TOTAL	940	989	10	12	6	117	78	2	2	25	41	4	1	3	300	31.9
				3.3	4.0	2.0	39.3	26.2	0.3	0.7	8.3	13.7	1.3	0.3	1.0		
							65.5										

Table 5. Percent composition by time and area for five principal spawning stocks captured in northern and southern Gastineau Channel in 1984.

Period	Date	Area	Fish Creek	Salmon Creek	Kowee Creek	Sheep Creek	Taku River
1	7/13	Northern	0	0	0	0	0
		Southern	0	0	0	3.1	24.0
2	7/19-20	Northern	10.0	0	16.7	3.1	0
		Southern	40.0	33.3	33.3	42.1	64.0
3	7/25-26	Northern	0	0	0	0.5	0
		Southern	0	8.3	16.7	27.2	8.0
4	8/01	Northern	10.0	25.0	16.7	3.1	0
		Southern	0	0	0	9.7	4.0
5	8/07	Northern	30.0	25.0	0	0.5	0
		Southern	10.0	0	16.7	10.8	0
6	8/17	Northern	0	8.3	0	0	0
		Southern	0	0	0	0	0
		Total	100.0	99.9	100.1	100.1	100.0

IV. The 1984 Stress Experiment

A total of 41 genetically marked adults with double fin clips (unquestionably of Auke Creek origin) and 43 unmarked control fish were tagged and released below the Auke Creek weir from August 31 through September 21, 1984. One double fin-clipped male was subsequently recaptured on September 22 in the intertidal portion of Waydelich Creek. I surveyed Waydelich Creek on September 22 and, upon observing the color of the Peterson disc, knew that the fish was part of the stress experiment. I observed the fish for several minutes. It was a male and had paired with a female who was actively digging a redd. Another male, an unmarked satellite, approached the pair and was driven off several times by the tagged male. I subsequently captured the tagged fish and positively identified the tag number and missing adipose and left ventral fins. The fish was mature and expressed milt freely. It had been tagged on September 16 and subsequently recovered and released at the Auke Creek weir on September 18.

Of the 41 fin marked fish, 11 (27%) were recovered a second time in the Auke Creek trap. Of these, one was recovered three times and one was recovered four times.

Of the 43 control fish, nine (21%) were captured a second time and of these, one was captured four times and two were captured three times.

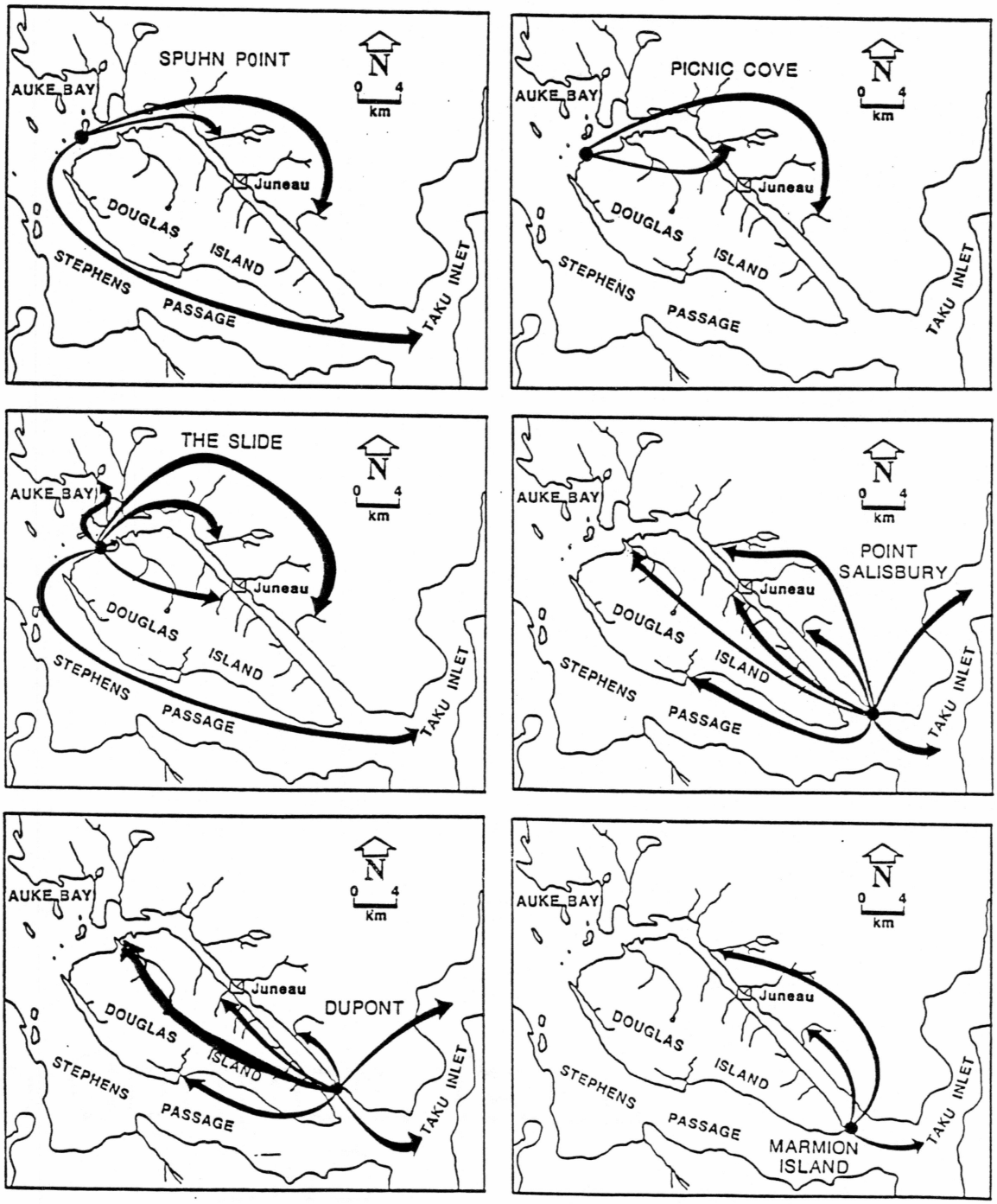

Figure 5. 1984 channel mouth tagging and recovery locations by tagging location.

Many of the tagged fish were observed spawning in the intertidal zone below the weir. No other recoveries of fish from this experiment were made outside of Auke Creek.

Discussion

The main objective of the 1982 stream mouth experiment and the 1984 channel mouth experiment was to gain a better understanding of the movement patterns of pink salmon as they near their natal streams, congregate near stream mouths, and choose a spawning site. The 1982 homing experiment and the 1984 stress experiment were designed to provide insight to the degree of accuracy with which the natal stream is chosen and if stress, such as handling and tagging, could affect that choice.

The 1984 Channel Mouth Tagging Experiment

The tagging in 1984 at the northern and southern ends of Gastineau Channel was designed to determine if those areas were principal milling areas for local stocks and to estimate the stock composition in each area. Of particular interest was the timing of the runs through these areas and the entry route to the channel used by the different runs.

The seining was funded by the ADF&G to examine the sampling areas for species composition and abundance and to determine if these areas would be suitable for the harvest of surplus hatchery production of pink and chum salmon. Catch by set for all species is presented in Appendix Table 10.

Catches at two of the three south end sites (DuPont and Salisbury Point) accounted for the vast majority of fish captured. The Marmion Island site produced very few fish and only four tag recoveries (two at Sheep Creek, one at Salmon Creek, and one in the gillnet fishery). In 1984, the southeastern shoreline of the channel appeared to be the favored milling area as determined by catches and observation. Of the tags recovered from Gastineau Channel streams from the south end tagging, (Table 6) 92.7% were recovered from Sheep Creek, 2.6% from Salmon Creek, 2.6% from Fish Creek and 2.1% from Kowee Creek. Comparing these recoveries to the estimated run size for each of these streams (Table 8), the G-test (log likelihood ratio) indicates that the proportions recovered are significantly different than what would be expected ($G = 17.24993 > \chi^2_{.005[3]} = 12.8$). Recoveries for Sheep Creek were substantially higher than would be expected and Salmon Creek, Kowee Creek and Fish Creek all lower than would be expected if the fish were mixing in this area in the same proportion as their run sizes.

Catches in the northern end were much smaller than those in the southern end with a somewhat different stock composition. Recoveries in Gastineau Channel streams of fish from the north end tagging were also predominantly in Sheep Creek (56%) followed by Salmon Creek (22%), Fish Creek (16%) and Kowee Creek (6%) (Table 6). These recoveries indicate the opposite trend, when compared to the recoveries from southern end (Table 7). In the north end, Fish Creek and Salmon Creek

had more recoveries than would be expected and Sheep Creek had fewer than expected if the stocks had been mixed in ratios proportional to their run strengths ($G = 12.22549 > \chi^2_{.005[1]} = 7.9$).

Table 6. Stream recoveries of pink salmon tagged in 1984 in northern and southern Gastineau channel and recovered in Gastineau channel streams.

	Tagging Area					
	Northern		Southern		Total	
Stream	Number Recovered	Percent of Total	Number Recovered	Percent of Total	Number Recovered	Percent of Total
Fish Creek	5	18	5	2.6	10	4.5
Salmon Creek	7	25	5	2.6	12	5.4
Kowee Creek	2	7	4	2.1	6	2.7
Sheep Creek	14	50	181	92.8	195	87.4
Total	28	100	195	100.1	223	100.0

Table 7. Estimated run size and date of largest observed escapement of pink salmon for Gastineau Channel area streams and the Taku River, 1984.

Stream	Estimated Run Size	Date of Largest Observed Escapement
Auke Creek	5,271[1]	8/25 (mid point)
Bullion Creek	675	8/31
Eagle Creek	125	9/05
Fish Creek	5,250	8/26
Gold Creek	300	9/01
Kowee Creek	2,250	8/21
Lawson Creek	150	9/05
Lemon Creek	25	9/05
Montana Creek	15	9/06
Nevada Creek	100	8/31
Peterson Creek	465	9/03
Ready Bullion Creek	8	8/31
Salmon Creek	6,000	8/28
Sheep Creek	65,000[2]	8/31
Switzer Creek	5	9/05
Total	90,889	
Taku River	168,000[3]	7/21[4] (mid-point)

[1]National Marine Fisheries Weir Count

[2]Includes estimated sport fish harvest of 5,000 (ADF&G) and cost recovery harvest.

[3]Estimated by Canadian Department of Fisheries and Oceans.

[4]From fish wheel counts, Canyon Island, Alaska Department Fish and Game.

Run composition by time and area is given in Table 8. For the first week of tagging (July 13), of the four principal Gastineau Channel stocks and the Taku River stock, only Sheep Creek and Taku River stocks were present. The number of recoveries was small, however, and recovery of tags from the Taku River was incomplete at best. Considerably more fish were captured, tagged and recovered during the second sampling period (July 19-20). All of the principal Gastineau Channel area stocks were represented in that time period and the relative proportion of Taku River stock declined while that of Sheep Creek increased (Table 9). The third sampling period (July 25-26) saw a continuation in the decline of the relative proportion of Taku River fish and an increase of the Sheep Creek stock. This order of timing is consistent with results of Larson (1978) who concluded that the Taku River stock could be classified as an "early run stock" and the Fish Creek stock (the parent stock in use at Sheep Creek Hatchery) as a "middle run stock". This is also consistent with their relative run peaks in freshwater (Table 8). Fourth and fifth period tagging (August 1 and 7) showed a similar trend and by the sixth sampling point (August 17), only 20 fish were captured in both areas combined. Because of the low number of recoveries in Salmon, Fish and Kowee Creeks, little can be said of the timing of these stocks. Freshwater run timing for all the channel stocks is very similar (Table 8). Recoveries of the Salmon Creek stock however, were only from the south end tagging in periods two and three and only from the north end tagging in periods four, five and six.

Table 8. Percent composition by tagging area and period for the five principal spawning stocks captured in Gastineau channel in 1984.

Period	Date	Area	Fish Creek	Salmon Creek	Kowee Creek	Sheep Creek	Taku River	Total	Number Recaptured
1	7/13	Northern	0	0	0	0	0	0	0
		Southern	0	0	0	50.0	50.0	100.0	12
2	7/19-20	Northern	12.5	0	12.5	75.0	0	100.0	8
		Southern	3.7	3.7	1.9	75.9	14.8	100.0	108
3	7/25-26	Northern	0	0	0	100.0	0	100.0	1
		Southern	0	1.8	1.8	93.0	3.5	100.1	57
4	8/1	Northern	9.1	27.3	9.1	54.5	0	100.0	11
		Southern	0	0	0	95.0	5.0	100.0	20
5	8/7	Northern	42.9	42.9	0	14.3	0	100.1	7
		Southern	4.3	0	4.3	91.3	0	99.9	23
6	8/17	Northern	0	100.0	0	0	0	100.0	1
		Southern	0	0	0	0	0	0	0

The relatively low numbers of fish caught in Fritz Cove suggests it is a far less important milling area for the Sheep Creek stock than for either the Fish Creek or Salmon Creek stocks. No fish were recovered in the Taku River that had been tagged at the north end. This appears to contrast with the conclusions of Larson (1979) and Rich and Suomela (1929) that describe a movement around the north end of Admiralty Island (Point Retreat, Figure 1) and southward into the Taku Inlet of the Taku River stock. Possible explanations of this discrepancy would be: 1) the Taku fish migrated earlier in 1984 than the tagging effort; 2) they used the Admiralty Island side of the passage; or 3) they used Frederick Sound as a primary migration corridor and migrated northward into Taku Inlet. The same could be said of the Sheep Creek stock except in this case the tagging period clearly encompassed the beginning and ending of the run. It seems possible that in 1984, significant portions of both Sheep Creek and Taku River stocks migrated from the south through Frederick Sound and lower Stephens Passage.

Only two marked fish were recaptured by the seine gear. Both had been tagged the previous week in the same area (south end). This low number of recaptures suggests that the fish migrate through quickly and that extended milling does not occur in these areas. It is also possible, although unlikely, that very large numbers of fish were present, and we sampled only a small portion.

The 1982 Stream Mouth Tagging Experiment

The purpose of the stream mouth tagging was to determine if the assemblages of fish near stream mouths in Gastineau Channel were composed of more than one stock. The results indicate a high variability in movement between tagging sites. Lawson Creek tagging demonstrated a large movement (74%) away from that site, and Sheep Creek a relatively small movement (4%) away. This large variability suggests true differences in stock composition at stream mouths as opposed to straying that could be associated with tagging and handling stress.

In general, it appears that the movement of adults away from stream mouths is primarily to the nearby (closest) spawning streams. Factors that might influence this movement could be the relative magnitude of the nearby spawning runs (Table 9), if the spawning streams were located along the same shoreline, and, perhaps, the similarity of stream type. Fish moving away from Bullion Creek moved to Nevada Creek (closest nearby run), Sheep Creek (next closest and substantially larger but across the channel) and to streams northward (the majority of the channel escapement). Movement away from Lawson Creek was primarily to Kowee Creek (closest and largest) with some movement to almost every local stream except Bullion and Sheep Creeks (south) and Eagle Creek. Movement away from Kowee Creek was primarily northward to Eagle Creek (closest northward) and Salmon Creek (north)

Table 9. Estimated run size and date of largest observed escapement of pink salmon in Gastineau Channel streams, 1982.

Stream	Estimated Run Size	Date of Peak Observed Escapement
Auke Creek	10,000	8/28 (mid-point)
Bear Creek	90	8/29
Bullion Creek	1,000	8/29
Eagle Creek	500	8/31
Fish Creek	17,500	9/11
Gold Creek	40	8/22
Kowee Creek	10,000	8/26
Lawson Creek	550	8/29
Nevada Creek	90	8/29
Ready Bullion Creek	40	8/31
Salmon Creek	4,000	8/27
Sheep Creek	4,750	8/22
Switzer Creek	75	9/07
Total	48,635	

with some movement southward to Lawson Creek (closest southward). There were no recoveries of fish tagged at Kowee Creek in either Sheep or Bullion Creeks (south). Both Sheep and Salmon Creeks had relatively low amounts of movement away from the stream mouths with one fish from Sheep Creek being recaptured at Salmon Creek and two fish from Salmon Creek being recovered in Kowee Creek.

Low movement rates away from Salmon Creek could be explained by the high intertidal position of the weir, which was the primary tagging site, and that the tagged fish were released upstream of the weir for the first portion of the study which produced no stray recoveries. The weir had a downstream trap which allowed downstream passage, however the structure could have imposed a barrier to fish that would have otherwise left the system. Only males were tagged (as at Kowee Creek) and when they were captured they were always in spawning condition. This could have also reduced the probability for movement to other streams since fish in spawning condition (freely running milt) have presumably made their stream selection. Tagging methods and location relative to the stream mouth were virtually identical at Sheep Creek and Lawson Creek, which has the lowest and highest movement rates, respectively. This clearly indicates a stock assemblage difference due to geographic location, relative run size and/or proximity of nearby spawning streams.

Jones and Thomason (1984) also reported similar results. Their work was conducted in southern Southeast Alaska in the same year as this study. Their objective however, was to estimate run size from tagged to untagged ratios in various spawning runs. Fish were captured and tagged at the stream mouths by beach seine assuming that the fish would migrate up that particular stream. They discovered that fish tagged at one stream mouth were often recovered spawning in another stream. They observed movement away from the tagging sites to other streams at 11 of 12 sites with lowest movement rates from fish tagged off stream mouths near the head end of inlets (Traitors River; McHenry's Inlet; Union Bay), and those tagged in freshwater (Cow Creek). The greatest rates were from those tagged within an embayment having several spawning runs (Rudyerd Bay) and those emptying directly into a major migration corridor (Eagle Creek). Stream mouth tagging by Helle (1966) at Olsen Creek in Prince William Sound also showed largest movement to the streams within the bay and less movement to those just outside.

Migration within Gastineau Channel in 1982 appeared to be generally northward. The largest movement between stream mouths was predominantly to the nearest stream with relative run size and geographic location appearing to be correlating variables. The stream mouth sites with the highest stock heterogeneity were Lawson Creek and Bullion Creek. Sheep Creek had the lowest.

Approximately 45% of the tags were recovered, therefore, 55% of the tagged fish died (handling stress, predation, etc.), lost their tags, went undetected in the spawning streams, were captured but not reported by commercial or sport fishermen, or spawned undetected in streams away from the study area. Probably a portion of the missing fish can be attributed to each cause. Given the intensity of the stream surveys in the study area, tag loss due to misdetection in the local spawning streams is likely to have been very low.

The 1982 Homing Experiment

The freshwater tagging experiment conducted in 1981 at Salmon and Auke Creeks was designed primarily to determine the extent native stocks, which had no history of transplantation, would return to spawn in their natal stream. Coded-wire tags were used successfully for the first time on emergent pink salmon fry to be able to positively identify returning adults without the ambiguities of fin regeneration that confounded results of earlier researchers.

Recoveries of coded-wire tagged adults at Salmon and Auke Creeks in 1982 were low (17 and 4, respectively). This was due, presumably, to low marine survival caused by environmental conditions or high fishery interception rates. An intensive search of local spawning streams produced no tagged recoveries. I recovered a single fish with a missing adipose fin (but no coded-wire tag) at both Kowee and Bullion Creeks. Both fish were recovered in the stream mouth tagging experi-

ment and might have continued to migrate to Salmon Creek or been fish with a naturally missing fin. These results indicate that straying of native Salmon Creek stock was probably very rare or nonexistent in 1982.

In 1931, Davidson (1934) conducted fin-clipping experiments on pink salmon fry in the Duckabush River in Washington State and in Snake Creek, Southeast Alaska. The double fin mark he used provided positive proof of returned adults but the recovery of adults missing one fin confused the estimate of the straying rate. Double fin marks did show straying to streams near the Duckabush (although recoveries were very few) but no straying of the Snake Creek fish was detected. Pritchard (1939) discounted the concerns of Davidson about fin regeneration and used a single fin mark at McClinton Creek in British Columbia. A massive tagging and recovery effort did result in the detection of a low level of straying in that stock. Davidson, however, would discount those results because of the potential presence of fish with a naturally missing fin. Reports by other researchers (Rukhlov and Lyubayeva, 1980) that document straying in pink salmon have dealt primarily with transplanted stocks which probably show an increased propensity for straying.

Straying has occurred at Sashin Creek, Southeast Alaska (Harry and Olsen, 1963) but no measurement of the magnitude of straying was possible in their study. Straying does occur in pink salmon populations but

the magnitude that it occurs and circumstances under which it occurs remain clouded. The second of the 1984 experiments hoped to address whether man-made stressors could induce it.

The 1984 Stress Experiment

The other portion of the 1984 experiment was to introduce a stressor (denial of access to part of the stream, tagging and handling) to the returning tagged adults to observe if they would leave their natal stream and spawn in another. This was not possible in 1982 because of the poor return of tagged adults and the need to evaluate the coded-wire tagging of fry as a tool (Thrower and Smoker, 1985). In 1984, the experiment was conducted at Auke Creek with adults that I had double-fin marked as fry in 1983. Both unmarked controls and fin marked test fish were tagged. Only one fish was recovered in another stream out of 83 fish tagged. That fish was of the double-fin marked group. The nature of that recovery (see Results) proved conclusively that at least one fish, native to Auke Creek, had migrated and spawned in another stream. This is the first positive evidence that a pink salmon, known to be native to one stream, had migrated and spawned in another stream in response to stress.

Circumstantial evidence of stress-related straying from the natal stream also occurred in the 1982 stream mouth tagging experiment. During that experiment, two fish tagged in Salmon Creek as mature males (freely running milt) were subsequently recovered and used in a

hatchery spawning at Kowee Creek a few days after a large rain storm and flood destroyed the weir at Salmon Creek. In this case, both males were in spawning condition and could have mated with females in both streams. The implication here being that these fish, having only partially spawned in Salmon Creek when the freshet occurred, were washed out and entered another nearby spawning habitat where they could have subsequently spawned.

A similar event occurred at Bullion Creek in 1982 when one fish (also a male) was captured and tagged at the stream mouth on August 24, as a dark but immature fish. It was recovered September 1, as a mature fish in Bullion Creek (in freshwater with other spawning fish) and returned to the creek. The same fish was recovered four days later in Nevada Creek, still in good condition, with freely running milt.

The circumstantial evidence, combined with the actual evidence in the case of the Auke Creek fish demonstrates that pink salmon will spawn in a non-natal stream given the appropriate circumstance. Quinn (1984) predicts this outcome and elaborates by hypothesizing that straying, as the result of unfavorable home stream conditions (excessive stream flows, predation, habitat alteration, etc.) would tend to be higher from unstable streams (steep gradient, non-lake fed) than more stable systems. This is because spawners from a relatively stable environment might be more specialized in their spawning requirements and less likely to produce offspring by straying. I suspect the degree of stress induced straying is dependent upon the duration or severity

of stress, the time during the spawning life of the fish in which it occurs, and the probability of encountering another spawning environment similar to the natal one within the time available to the individual fish.

These four experiments attempted to provide a better understanding of: the movement of maturing pink salmon in and around Gastineau Channel; their movements between stream mouths; their ability to home to their natal stream; and the reactions of maturing fish to a specific stress. Only the 1980 and 1982 brood years were involved in this study. It is therefore presumptuous to draw conclusions from this for pink salmon in general, particularly the odd year line. The migration route to and into Gastineau Channel could vary considerably from year to year, especially between lines. Sockeye salmon in British Columbia have chosen different routes around Vancouver Island on their way back to the Frazer River (Groot et al. 1984). Behavioral differences could exist between lines and years of pink salmon in their schooling behavior at stream mouths and in their response to stress while in the stream. While general migration routes and timing are probably affected by oceanographic conditions, homing and response to stress on the spawning grounds are probably determined by biological imperatives such as the amount of time before spawning and the suitability of the spawning habitat. Even given these constraints, it is now clear that pink salmon generally home to their natal streams with a high degree of accuracy. The final spawning site, however, appears to be dependent

upon the suitability of spawning conditions encountered, suitable spawning conditions being those whose cumulative stress factors are below that level which would result in stress induced straying.

General Implications

While the primary goal of these experiments was to learn more about the biology of this dynamic animal, the results have far reaching and diverse management implications. Typically, additional research on the behavior of an organism yields results which reveal more complex behavior patterns than originally perceived and, in the case of commercially important fishes, tends to complicate their management. While some results of this research certainly indicate behavior more complex than earlier perceived and which by themselves tend to complicate management strategies, other results imply a broader definition of the stock concept and therefore might actually lessen management complexities.

The results of the 1982 stream mouth tagging experiments clearly demonstrate that complex assemblages of runs exist at the mouths of particular streams during the spawning migration. This demonstrates that the practice, previously common, of estimating escapements for a particular stream from aerial survey counts of fish congregating at the mouth could be grossly incorrect. The degree of error would be dependent upon the proximity of other runs, their relative run size, and the general geographic composition of the area adjacent to the stream. For

those runs in close proximity or on migration corridors, accurate escapement information can only be obtained by counts of fish in freshwater.

In the Gastineau Channel area, intensive harvesting near a stream mouth such as that at Sheep Creek will probably reduce escapement in other Gastineau Channel streams even though the run composition during this study appeared relatively homogeneous there. Because of the current restrictions in place on the size of that harvest area, and the general migratory patterns observed in this study, it seems highly unlikely that the harvest activity in any way threatens runs to other Gastineau Channel streams. If the southern harvest area was expanded substantially and Fritz Cove was also used as a harvest area, then substantial reductions in escapements to Gastineau area streams could be expected. When examined in the context of productivity, however, the overall productivity of the hatchery system far exceeds the capacity of local natural systems. Indeed, returns to Sheep Creek and Kowee Creek Hatcheries in recent years (1985-1987) have exceeded one million adults which probably exceeds the total production of the natural systems in the Gastineau area for the last 50 years.

This large production could have other effects on the local natural systems. The coded-wire tagging experiment in 1982 failed to detect any inaccuracy in homing ability of hatchery produced pink salmon. Genetic marking experiments in Auke Creek have also failed to detect straying to other systems and in fact, have revealed substantial

within run segregation in the Auke system (Gharrett and James). This information supports the idea that pink salmon are accurate and precise in their homing ability. Work by earlier researchers (Hartman and Raleigh, 1964) demonstrated that salmon, in this case sockeye, were not only accurate in homing but tenacious as well. In one experiment in Karluk Lake, maturing adults were not allowed to re-enter the spawning stream originally selected and were returned to the lake, in most cases - many times, until they finally disappeared and were never observed spawning in any other tributary of the lake. The spawning tenacity of pink salmon that spawn intertidally or a short distance above tide-water, as is most common in southeast Alaska, does not appear as great as the sockeye of Karluk Lake.

Results of the tagging work I conducted in 1982 strongly implied that some pink salmon may spawn in a non-natal system in response to stress. In that case, mature males were captured in one stream and subsequently re-captured in another stream. The stress experiment conducted in 1984 demonstrated clearly that straying and spawning in a non-natal system in response to stress does occur. Predation, habitat alteration and over-crowding are more common forms of stress that a pink salmon is likely to encounter which might induce spawning in a non-natal stream. All of these can and often do exist in the hatchery streams and exert their influence on a great many individuals. It therefore seems likely that stress induced straying from the hatchery streams does occur and, given the magnitude of the local natural runs and the potential magnitude of the straying, will eventually swamp the

local gene pools with those of hatchery origin. Stress induced gene flow is probably common among natural populations of pink salmon in close proximity and may contribute to their similar genetic composition. McGregor (1983) found substantial genetic homogeneity among regional pink salmon runs. The rapid colonization (the Great Lakes) and recolonization (Glacier Bay) of streams also demonstrates the relatively rapid movement of pink salmon genetic material among streams of geographic proximity.

This is, perhaps, the behavior which could simplify management strategies born out of concern for the survival of a particular run. Practically it appears that the stock concept, as it applies to pink salmon, could be based on broad geographic areas possessing many streams of similar habitat type and run timing. As natural extinctions of particular runs have occurred many times in southeast Alaska begat by movements of glaciers and changes in sea level, and these streams were relatively quickly re-populated, it seems that extinctions due to over fishing of a particular stream should rate similar concern. Undoubtedly, if populations in nearby streams continue, then the vacant stream will soon be re-populated. This is not to say that extinction or careless overharvesting is a viable pink salmon management tool, rather, run elimination or serious reduction which could be catastrophic for some species (chinook, coho), might not represent as large a threat to overall productivity or genetic variability of the species.

What could be implied from all this is that pink salmon might optimally adapt to a relatively broad range of environmental conditions in a particular geographic locale which ultimately maximizes the number of individuals produced as opposed to optimally adapting to the specific environmental conditions of a given stream. Alexandersdottir (1987) proposes a risk spreading concept whereby neighboring populations buffer each other, providing spatial structure instead of the age structure which buffers other species of salmonids.

Unfortunately for managers however, pink salmon population dynamics are not quite so simple. The evidence presented by Gritsenko (1981) suggests that there are as many as nine populations of the second order for pink salmon across the North Pacific with at least two and possibly three represented in southeast Alaska. He has divided these based upon spawning migration timing and oceanic distribution. Gharrett and James (1987) presents strong evidence that additional substructure within these second order populations may exist in some systems. Ultimately, the ability of a freshwater system to support different subpopulations is probably dependant upon the diversity of habitat types present within the system and the regional existence of various subpopulations. The presence or absence of a particular habitat type within a geographic locale will ultimately determine the number of viable discrete runs of that particular stock. If the number of suitable habitat types is very limited within a particular locale, it seems likely the level of stress required to induce straying would be relatively high because the probability of finding suitable

alternative spawning habitats would be low. Conversely, in areas where many similar spawning habitats exist in close proximity, such as intertidal spawning habitat in many areas of southeast Alaska, the level of stress required to induce straying might be relatively low because of the high probability of finding suitable alternatives. Within this type of population structure, therefore, one could expect to find substantial population substructure within a given stream with diverse habitats and, within that substructure, some populations which have a high propensity for straying and others with a low propensity for straying. One potential test of this would be a tagging experiment on a system known to contain a pink salmon run with substantial population substructure such as Auke Creek. Early and late run fish, and intertidal and above tide spawners could be stressed by tagging and their movements monitored to determine to what degree tagging stress affected their final spawning site selection.

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Appendix Table 1. Catch by date and site for the 1984 Gastineau Channel test fishery.

		Pinks		Chum					
Date	Location	Tagged	Untagged	Tagged	Untagged	Sockeye	Coho	Chinook	Dolly Varden
7/13	Spuhn Point	0	0	9	2	0	0	0	0
7/13	Picnic Cove	3	1	189	3*	0	0	0	0
7/13	Slide	0	1	86	125+8*	0	0	0	0
7/13	Salisbury	75	10	1	0	10	0	0	0
7/19	DuPont	41	0	1	0	1	0	0	0
7/19	Salisbury	264	20	9	0	20	0	0	2
7/19	Marmion	5	1	3	0	1	0	2	1
7/20	Slide	7	0	104	1+3*	1	0	3	0
7/20	Picnic Cove	4	0	30	1*	1	0	1	0
7/20	Spuhn Point	6	5	150	206+9*	2	1	1	0
7/25	DuPont	95	0	6	0	7	0	1	0
7/25	Salisbury	65	0	6	0	4	0	2	2
7/25	Marmion	7	0	0	0	4	0	0	2
7/26	Slide	5	0	26	2*	0	0	1	0
7/26	Picnic Cove	0	2	175	1,167+14*	0	0	1	0
8/01	DuPont	23	1	0	0	0	0	1	1
8/01	Salisbury	115	4	0	0	5	1	1	2
8/01	Marmion	0	0	0	0	0	0	1	0
8/01	Picnic Cove	4	0	6	0	0	1	0	0
8/01	Slide	20	0	6	1	0	1	0	0
8/01	Spuhn Point	29	0	7	3*	0	3+1*	0	0
8/07	Spuhn Point	2	0	0	1	0	0	0	0
8/07	Slide	30	1	0	0	0	0	0	0
8/07	Picnic Cove	1	0	3	0	0	3	0	0
8/07	DuPont	37	0	4	0	5	0	0	0

Appendix Table 1. (Continued)

Date	Location	Pinks		Chum		Sockeye	Coho	Chinook	Dolly Varden
		Tagged	Untagged	Tagged	Untagged				
8/07	Salisbury	79	2	2	0	12	0	0	0
8/07	Marmion	4	0	1	1*	0	0	0	0
8/17	DuPont	2	0	0	0	2	0	2	0
8/17	Salisbury	6	0	4	0	4	0	0	0
8/17	Marmion	1	1	0	0	0	0	1	0
8/17	Picnic Cove	2	0	5	0	0	3+1*	1	0
8/17	Slide	7	0	0	0	0	1+1*	4	0
8/17	Spuhn Point	1	0	5	0	0	5+2*	0	0
33 Sets		940	49	838	1,503+44*	69	19+5*	23	10
Fritz Cove Totals		121	46	801	1,503+43*	4	18+5*	12	0

*Previously tagged fish (Floy, disc or coded-wire).